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OBSERVATIONS ON SOME NESTS OF *CROSSOCERUS* (*BLEPHARIPUS*) *A. ANNULIPES* (LEPELETIER AND BRULLÉ) (HYMENOPTERA: SPHECIDAE)

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Abstract.—Ten nests of *Crossocerus* (*Blepharipus*) *annulipes annulipes* found in a rotting log in Pennsylvania are described and figured. Thirty fully-provisioned cells contained from 14 to 30, mostly adult Cicadellidae per cell. Two new cicadellid hosts, *Ribautiana unca* and *Typhlocyba hockingensis,* are reported from the cells. Two cells contained nymphal Miridae and one an adult Chironomidae and nymphal Miridae in addition to the adult and nymphal cicadellid prey.

Crossocerus (*Blepharipus*) *annulipes annulipes* (Lepeletier and Brullé) is widely distributed in the Holarctic Region; in North America north of Mexico the subspecies ranges from southern Canada into Georgia and California (Krombein, 1979). The other subspecies, *C. annulipes hokkaidoensis* Tsuneki, occurs in Japan (Tsuneki, 1960). Much of the biological information available for *C. a. annulipes* has resulted from studies done in Europe (summary in Leclercq, 1954). Although there are numerous prey records for this subspecies from the United States (see Krombein, 1979), detailed descriptions and figures of the nests are lacking. Davidson and Landis (1938) first reported on the life cycle, prey and cocoon of *C. a. annulipes* (as *Crabro davidsoni* Sandhouse) in North America (Ohio). Their report includes an excellent drawing of prey placement within a cell. Krombein (1958) noted the contents, including prey, of two cells of this subspecies [as *C. ambiguus* (Dahlbom)] in Virginia. Michener (1971) described the burrow, cell and contents of a "few cells" of *C. a. annulipes* (as *C. ambiguus*) in Kansas. The above-mentioned studies indicate that the subspecies nests in abandoned insect burrows in rotting stumps and logs and structural timber.

We found ten active nests of *C. a. annulipes* in a rotting log near the base of Presque Isle State Park, Erie County, Pennsylvania. Two of the nests were located in the top and four near either end of the log. They were discovered just above 2–3 cm-high and 3–4 cm-wide piles of sawdust, indicating recent burrow enlargement (excavation). The log, 91 cm long and 17 cm in maximum diameter, lay exposed on a flat, mixed sand and gravel surface, 2.5 m from a gravelly cliff and deciduous woods.

We observed eight females of *C. a. annulipes* between July 4 and 15, 1972, entering open nests with leafhopper prey and exiting headfirst seconds later. Some of the wasps, upon leaving, made 5–10-sec-long orientation flights, 40–60 cm in

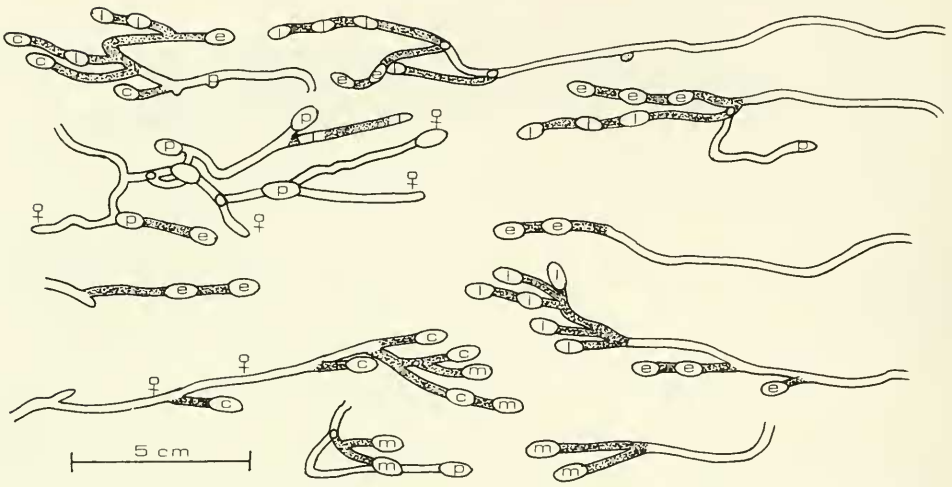

Fig. 1. Ten nests of *Crossocerus* (*Blepharipus*) *a. annulipes,* as viewed from the side. Cell contents are as follows: c, cocoon; e, egg; l, larva; m, mouldy prey; p, prey only. Stippling indicates burrow filled with sawdust and frass. ♀ shows position of collection of female(s) inside two nests. Scale refers to all nests.

length, along the long axis of the log. They then flew away rapidly and returned in flight minutes later holding the prey with the legs in a head forward position.

The burrows, 2.5–4.0 mm in diameter, entered the log at various angles to its surface but then turned abruptly or gradually and proceeded along the grain of the wood. The often elongate main burrows ranged from 2.8 to 16.0 cm in length (Fig. 1). Some of the burrows led to cells near their distal ends, whereas others gave rise to cells along most of the burrow. Not more than three cells were found in a series, each separated by sawdust and beetle frass. Some long nests contained only a few cells in series, most cells being positioned singly at the ends of short side burrows packed with sawdust and frass. One nest contained a storage chamber in the opposite direction of three cells, and other nests had prey stored in small chambers or in the burrows. In all nests the main burrow and in some the side burrows were open.

Cells (N = 26) containing prey and eggs, larvae or cocoons averaged 3.4 (3–4) mm wide and 8.3 (7–9) mm long. They were located roughly in the middle of the log, and were separated from neighboring cells by from 5 to 35 mm (Fig. 1). Cells containing a wasp's egg, larva or cocoon were sealed off from neighboring cells or the main burrow with sawdust and frass.

The number of prey placed in a fully-provisioned cell ranged from 14 to 30 ($\bar{x}$ = 21.4, N = 30). Prey individuals weighed (wet) from 0.3 (nymphal cicadellid) to 2.2 (adult cicadellid) ($\bar{x}$ = 0.74, N = 268) mg. The total weights of all prey in a fully-provisioned cell ranged from 12.6 to 22.0 ($\bar{x}$ = 15.86, N = 14) mg. Three females of *C. a. annulipes* collected in association with nests weighed (wet) 6.9, 7.3 and 9.1 mg, respectively. (Two males collected on the log weighed only 2.9 and 3.7 mg, respectively.)

Only one cell contained adult cicadellid prey exclusively; 26 others held a preponderance of adults but also contained some nymphal Cicadellidae. Of 642 prey Cicadellidae, 470 (73%) were adults and 172 (27%) were nymphs. A sample

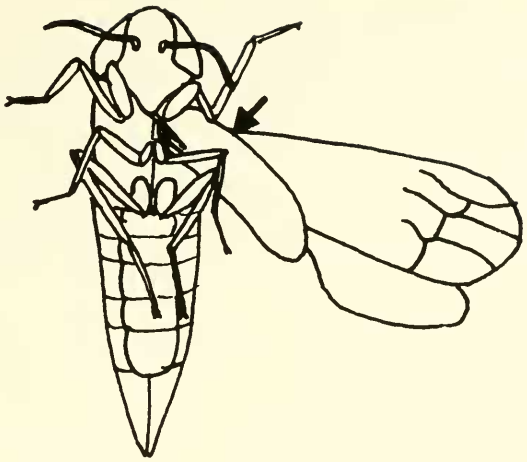

Fig. 2. Location of egg (arrow) of *Crossocerus* (*Blepharipus*) *a. annulipes* on prey Cicadellidae.

of prey Cicadellidae, all of the subfamily Typhlocybinae, is as follows: *Erythroneura* sp., 1 ♀ ; *Empoa* sp., 2 ♀♀ ; *Empoasca fabae* (Harris), 8; *Ribautiana unca* (McAtee), 4; *Typhlocyba hockingensis* Knull, 27; and, *T. pomaria* McAtee, 2. *R. unca* and *T. hockingensis* are new prey species for *C. a. annulipes.* Two cells each contained three nymphal mirids in addition to adult and nymphal cicadellid prey, and one cell held two nymphal mirids and one adult chironomid mixed with adult and nymphal cicadellids.

Prey were "stacked" rather neatly in a cell in a mostly head inward but rather oblique position (see Davidson and Landis, 1938, Fig. 3). Rarely, one or a few prey in each cell were placed straight inward with the head against the back of the cell. The egg-bearing leafhopper was invariably positioned head inward and ventral side upward at the inner end of the cell. Of 10 such prey bearing eggs, seven were female Cicadellidae. The wasp's egg was affixed ventrally near a forecoxa, just off-center of the prey's thoracic midline (Fig. 2). The wing nearest the egg's attachment was flexed at a 60°–90° angle to the midline. One egg affixed near a left forecoxa was 1.7 mm long and 0.4 mm wide at its center.

Five cocoons removed from the cells of *C. a. annulipes* were 2.5–3.0 mm wide × 7.0–7.5 mm long. Two were covered with sawdust and beetle frass and three others contained, in addition, prey remains embedded at one end.

Two nests had more than one female wasp associated with them. One nest (RCM 2) had a female stationed head outward in the burrow, 4 cm below the entrance, and another female, 3 cm behind her in the same burrow. Both wasps had each appeared with their head inside the entrance a few minutes earlier. Another nest (FEK 1) contained four females collected at various locations within, as indicated in Fig. 1. Whether or not these females were actively participating in burrow enlargement, cell construction, and provisioning, or, were simply recent emergents from cells of a previous generation is unknown.

Discussion

Crossocerus (*Blepharipus*) *annulipes* is an extremely successful species as indicated by its extensive distribution in the Holarctic Region (see Leclercq, 1954;

Krombein, 1979). This success is undoubtedly related to the wide variety of plant materials and structural timbers in which the species nests (see Leclercq, 1954, for list of plant genera). The nesting season of *C. a. annulipes* was only a little over a month old when our study site (log) was found. The daughters being reared within the cells might have utilized remaining space in the log for rearing their young until the end of the season if the log had remained in the field. An additional 40 nests could have fit easily within the remaining space of the 91 × 17 cm rotting log. If a finished nest contains a modest estimate of seven completed cells, as did several unfinished ones, then the log we examined could have held a total of 350 cells by season's end.

In some studies (Krombein, 1958; Michener, 1971; and the present report) the wasps appeared in part to utilize the abandoned burrows of other insects, evidently those of bees and beetles. Nevertheless only a few of the cells (never more than three) were constructed in series, indicating that the wasps must have diverged from the pre-existing insectan burrows in order to construct cells. This is totally unlike the situation in some other crabronine wasps in which most or all of the cells are built in series (see Tsuneki, 1960; Krombein, 1967; Miller and Kurczewski, 1972).

Although Davidson and Landis (1938) cited the cells of this subspecies as being ¼–½ inch in length, none of the cells we excavated and measured were as short or as long as this. The cells from our study were essentially identical in width and length to those recorded by Tsuneki (1960) for *C. annulipes hokkaidoensis* (3.0–3.3 × 7.0–7.5 mm). The mean number of prey per cell that we found (21.4) agrees with that reported by Davidson and Landis (1938) (20.4), except that their range of 4–46 prey per cell exceeds all figures reported in the literature for either subspecies of *annulipes*.

The total weight of all prey in a cell that we recorded for *C. a. annulipes* is approximately twice that for a female wasp and more than four times that for a male wasp. Although we lack substantive data for this subspecies, it is believed that males are produced from cells containing either fewer prey or less biomass and females from cells containing more prey and biomass; at least this is the case in some other crabronine species (see Evans et al., 1980).

Studies of both subspecies of *C. annulipes* indicate a preference for adult cicadellid prey, with a preponderance of typhlocybine leafhoppers (see Leclercq, 1954; Krombein, 1979). Although all previous nearctic studies indicate the exclusive use of typhlocybine Cicadellidae as prey, we found that three of 30 (10%) cells contained either nymphal Miridae or nymphal Miridae and adult Chironomidae in addition to adult and nymphal leafhoppers. This corroborates the findings of Hamm and Richards (1926) and Bristowe (1948) in England.

The positions of the prey in the cells that we observed agree with those described and figured for this subspecies by Davidson and Landis (1938). Tsuneki (1960) reported similar positioning of the prey in *C. annulipes hokkaidoensis*, except that several prey were "lying in the opposite direction." Tsuneki (1960) noted two eggs of this subspecies attached to the necks of prey and then extending either obliquely across the thorax or lying parallel with the longitudinal body axis of the prey. We found eggs of *C. a. annulipes* abutted against the forecoxae of the prey but not quite reaching the cervix. In general the eggs of crabronine wasps are affixed to the cervical region of the prey, except in rare instances as in *Oxybelus*

subcornutus Cockerell where the egg is attached to the base of a forecoxa (Peckham et al., 1973). Other sphecids that prey upon leafhoppers affix the egg variously but never in the region of the throat (see Iwata, 1942; Evans, 1966; Kurczewski and Lane, 1974).

Davidson and Landis (1938) noted that the cocoons of *C. a. annulipes* consist "largely" of pieces of leafhoppers, but we did not find this to be the case. Some of the cocoons we observed contained no prey parts and others had sclerites of Cicadellidae embedded only at one end. *Bothynostethus distinctus* Fox, a larrine with many crabronine characteristics, typically covers one end of its cocoon with beetle elytra (Kurczewski and Evans, 1972).

Our observations on two nests of *C. a. annulipes,* in which we found four females in one nest and two females in another, hint at communal nesting in this species. On the other hand, these females may have been recent emergents from a previous generation which had remained with the nests. Females of *Philanthus gibbosus* (F.) remain for a while with the nests from which they have recently emerged (Evans, 1973), and those of *Cerceris* may actually overlap in generations (Salbert and Elliott, 1979; Evans and Hook, 1982). Communal nesting in the Crabroninae in which two or more females actively participate in the provisioning of a single nest has been documented for the genera *Crossocerus* (Bristowe, 1948; Peters, 1973); *Ectemnius* (Hamm and Richards, 1926; Bristowe, 1948); *Lindenius* (Miller and Kurczewski, 1973); *Moniaecera* (Evans, 1964); and *Rhopalum* (Janvier, 1928).

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